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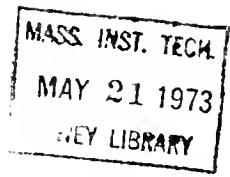
Institutional Roles in Technology Transfer

Thomas J. Allen and Sean Cooney

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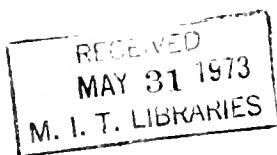
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INTRODUCTION

The rapid expansion of the world's store of scientific and technological knowledge presents the small nation with a particularly vexing problem in maintaining its scientific and technological communities abreast of foreign developments. To assure its survival and growth the small country must not only acquire foreign scientific and technological information, but it must also solve the more difficult problem of seeing that this information is disseminated to those points where it can be utilized.

This problem has been discussed extensively in recent years and numerous solutions have been proposed. The majority of these, however, are concerned only with the first problem, that of bringing information into the country (acquisition), and they either ignore or give only cursory treatment to dissemination. As many research laboratories have sadly learned, the mere possession of information does not guarantee its utilization by those who require it.

The problem of dissemination is a particularly difficult one. Most of the recent work in the field of technical information has gone into the development of hardware and software packages which provide at best, only partial resolution of the dissemination problem. National dissemination of scientific and technological information is highly dependent upon the ways in which science and technology are organized in the country, upon the existing institutional forms, and upon relations among both institutions and people. This is true whether the source of information is domestic or foreign. To advocate reorganizing or establishing new or additional institutions without first understanding the roles in the dissemination process of existing ones would indeed be foolhardy. As a

first step, a thorough investigation must be undertaken to ascertain the respective roles and the effectiveness of the various types of institution which exist in the country.

Similarly, acquisition mechanisms must be subjected to scrutiny. The allocation of resources to different methods of information procurement should be determined on the basis of their relative cost-effectiveness. Although considerable effort has been devoted to evaluating the effectiveness of information acquisition mechanisms, this effort has been, for the most part, restricted to the evaluation of hardware and software systems. Little is known about the human element in the acquisition processs. The effectiveness of mechanisms such as foreign training of scientists and engineers, employment of foreign nationals, attendance at international conferences, foreign sabbaticals, etc., must be determined. Since research into the dissemination process has shown the overwhelming importance of personal contact in this process, these approaches to acquisition appear to have a natural kinship with the dissemination system. They may prove to be more effective than all of the hardware, software and print-oriented devices combined.

Any country, whatever its size, would certainly benefit from a better understanding and evaluation of its strategies for acquiring and disseminating technical information. For the small, growing nation, however, the need is at once both more acute and more capable of fulfillment. Because of its size much more can be learned about the functioning of science in a small country. The entire country can be made a unit of analysis, and the entire scientific and technological community can be reached and studied in considerable detail, at reasonable cost.

Research Method

The techniques which have proven successful in studying industrial firms (Allen, 1971) have now been adapted to the study of technical communication patterns in the Republic of Ireland. The present is the first of a series of reports based on this study.

A survey was conducted in 1971 of the approximately 1500 engineers and scientists in Ireland. Responses were received from more than 1200, or 80 percent of this population. Of these more than one hundred either disqualified themselves or had to be disqualified for various reasons. The principal reason for disqualification was that the respondent had become completely involved in research administration, and was no longer an active researcher. A number of other respondents either answered questions in ways that were uninterpretable or gave answers that were unusable. For example, in responding to the question, "If you consistently (once a month or more often) discuss technical or scientific matters with anyone from outside your organization, please give the names of these individuals and their institutional affiliation," some people would say, simply, "Nine or ten people." A response of that sort just couldn't be used in the analysis, so for any given question the size of the sample was often further reduced, resulting in about 1000 questionnaires, plus or minus 25, that were analyzed on any given question. This is about two-thirds of the estimated population size, and should be large enough to provide results that are valid for the population, as a whole.

The questionnaire, itself, requested information on the usual demographic variables, such as age, education, field of research activity and years of technical experience, but in addition information was obtained

on each respondent's present and former employers both within and outside of Ireland, and on each respondent's communication activity at three levels: within his organization; within the country outside of his own organization; and outside of the country. Data such as these can be analyzed in many ways. The present paper is concerned only with the flow of information into and among the various research institutions in the country. Once communication measurements as these have been made at an individual level, it is a relatively straightforward task to aggregate them by specific organization, and to examine the relative strengths of communication bonds between organizations. This provides a measure of the extent to which technical and scientific information flows, via personal contact, from organization to organization or from sector to sector, within the country.

Since each respondent was asked to report the frequency (once a month; once every six months; etc.) with which he maintained contact with those outside his organization, the data will be analyzed in terms of a high frequency network (once a month or more frequent) and a low frequency network (less than once a month, but at least once a year).

The Communication Bond. In order to compare the amount of communication among organizations, an index had to be developed. There are many possibilities for such an index, none of which are completely satisfactory. The one which has been chosen is one which should allow valid comparisons to be made with a minimum of distortion to the data. The index is based on the number of individuals in any one organization who are named as communication partners by those in another organization.

$$C_{ij} = (2 \times 10^2) \frac{n_{ij} + n_{ji}}{N_i N_j} - \frac{N_j}{1-e^{-\frac{N_j}{10^2}}}$$

where:

C_{ij} = strength of the communication bond between organization i and organization j

$n_{ij}; n_{ji}$ = number of individuals in organization j or i who are named as communication partners by their counterparts in organization i or j

N_i = number of respondents in the larger of the two organizations

N_j = number of respondents in the smaller organization

The constant term is simply a scale factor, while the exponential term is a correction factor to offset the effect of wide differences in size of organization.

RESULTS

Sector to Sector Flow

There are three principal classes of organization performing research in Ireland. First of all there are four major universities, in which some of the staff perform research in conjunction with their teaching responsibilities while others are engaged solely in research. There are three major research institutes, which are supported primarily by government funds and which perform research for both industry and agriculture. Finally there are a number of industrial firms, both private and semi-state,¹ which support research and/or development work within their own organizations. These are but a very small proportion of Irish industrial firms, but it is important to see how they acquire technology, since it

¹ Semi-state firms are commercial organizations set up by Government statute.

is largely through these firms that the country will maintain its competitive position in world trade.²

As one might expect, the relative strengths of the bonds (Table I) show communication to be heaviest between research institutes and industry

Table I

The Strength of Sector to Sector Communication Bonds (Monthly or More Frequent Contact)

and between	Communication Bond (C_{ij})	research institutes	industry
universities	0.285		0.098
research institutes	--		0.422

and weakest between universities and industry. If the research institute is seen as an intermediary between more fundamental university research and the needs of industry,³ the communication bonds would indicate that they are performing one part of this function somewhat better than the other. The bond extending forward to industry is nearly one and one-half times that extending back to the university base.

Of course, the universities aren't the only source of new knowledge. In fact, the research institutes themselves may often be the leaders in creating new knowledge, particularly of the sort that would be relevant to industrial needs. So, to some extent the research institutes may be able to operate independently of the university and the communication with

²For a more general examination of how Irish industrial firms acquire new technology, see Allen and Reilly (1973).

³This is certainly not the only role of the research institute, but it nevertheless remains a very important one.

which it should really be concerned is the one with industry. In this sense, the situation presented in Table I is probably not a bad one, at all.

In addition to creating knowledge through their own efforts, the research institutes have developed a network of contacts with foreign universities, research institutes and firms. This network allows them to tap information sources elsewhere in the world, further lessening their dependency on domestic universities.

Foreign Contacts by Sector

The three research sectors differ both in the extent and amount of foreign contact by their research staff (Table II). Surprisingly, the

Table II

sector	Foreign Communication Index (C_{if})*
universities	0.851
research institutes	0.356
industry	0.449

$$*C_{if} = \frac{n_{if}}{N_i}$$

where: n_{if} = number of individuals in foreign countries with whom contact is reported by individuals in sector i

N_i = number of individuals reporting in sector i

three research institutes show the weakest foreign connections. It is not surprising to see the universities with strong foreign ties, particularly

to the U.K., but it is surprising to see a higher degree of direct foreign contact by industry than by the research institutes. The temptation is to explain this as a result of foreign ownership of industrial firms, but the fact that slightly more than half of the research staff in the industrial sector are employed by semi-state firms, quickly dispels such an explanation. A preponderance of the foreign contacts are maintained by private firms, but not even all of these are foreign owned, and nearly half of the foreign contacts, themselves, are employed by organizations other than industrial firms.

University contacts, in addition to being greater in number, are more evenly spread around the world (Table III). The research institutes and industry are more strongly dependent upon British sources for their information. This situation will undoubtedly be shifted somewhat with the

Table III

Location of Foreign Contacts by Sector

research sector	Great Britain	Continental Europe	United States	Other countries	North of Ireland*
universities	0.382	0.204	0.174	0.063	0.053
research insti- tutes	0.209	0.090	0.027	0.032	0.047
industry	0.291	0.120	0.019	0.019	0.006

* Not included as foreign in the totals

entry of Ireland into the European Economic Community. The links to the North of Ireland are uniformly weak. Of course, there are fewer contacts

available in the North, than in the U.S., Britain or Continental Europe. Even so, one would expect far more contact with a community of scientists who are culturally, linguistically and geographically so close.

The Flow from Institution to Institution

Within each research sector, are a number of institutions. These institutions are connected among themselves to varying degrees, and the coupling to other sectors varies considerably from one institution to the next.

The University Sector

Communication Among the Universities. The two major universities have between them a total of four campuses. The University of Dublin, or Trinity College (TCD) is located in Dublin. The National University comprises four separate campuses, at Dublin (UCD), Cork (UCC), and Galway (UCG). University College Dublin and Trinity College are by far the largest, accounting for about two-thirds of the research staff in the university sector. Communication between the two largest university centers is the best of the six possible pairings (Table IV). Despite the fact that UCD, UCC and UCG are all branches of the National University, their communication with TCD is just about as good (or as poor) as it is among themselves. The only exception is the link between University College Dublin and Cork, where moderately good communication exists. Galway is the most isolated of the four. It has slightly better communication with Trinity than with the other two, but the strength of even that link is hardly overwhelming.

The Position of the Universities. The universities are closer to the public sector than to any of the other segments of the research community

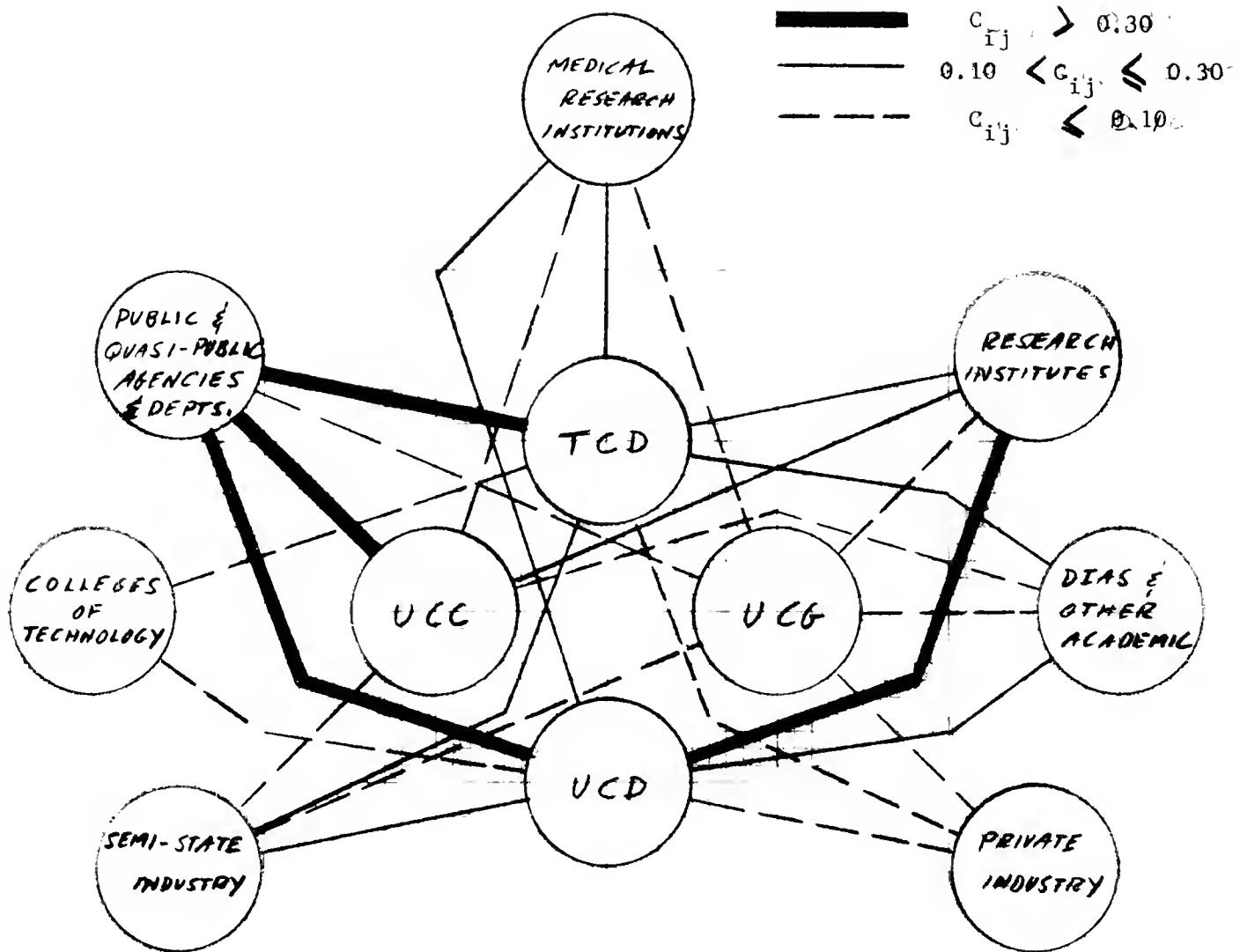
Table IV

Communication Among the Four Universities (Monthly or More Frequent Contact)			
	Communication Bond (C_{ij})		
	UCD	UCC	UCG
Trinity College Dublin	0.412	0.067	0.096
University College Dublin	-	0.236	0.079
University College Cork	-	-	0.040

in Ireland. Three of the four have very strong bonds (Figure 1). Only Galway, because of its geographic separation and poor rail service to Dublin has failed to develop strong contact. In the case of the research institutes, UCD is responsible for most of the university communication. Trinity and Cork have a moderate level of contact, while Galway's is light.

With regard to industry, only Trinity and UCD have achieved even a moderate level of communication, and then only with semi-state firms. None of the universities have even moderate contact with private industry.

The colleges of technology, medical research institutions (Royal College of Surgeons of Ireland, Medical Research Council and the hospitals), and other academic institutions show, at best, a moderate degree of interaction with the universities. In some of these, however, interaction would be expected primarily with but one part of a university (e.g., a medical school). Final judgment on this situation should await an analysis of university communication at the departmental level.



DIAS = Dublin Institute of Advanced Study

Figure 1. The Position of the Universities (Based on Communication Frequency of Once a Month or more often)

in Dublin (Year 1971)

That will be reported in a subsequent paper.

Foreign Contact by the Universities. Turning to foreign contact, all four universities show similar levels (Table V). Galway, somewhat surprisingly is the leader, showing an even higher level (proportional to its size) of contact with Britain than does Trinity. UCD has established the strongest ties to the continent, and along with Galway, leads in communication with the United States. Trinity has far more contact in the North, than the other three. This contact is primarily with Queen's University in Belfast.

Foreign contact is primarily with university personnel, although a high proportion is with the staff of "research institutes." This is something of a "catch all" category for all laboratories that are not clearly universities or industrial. It includes personnel from foreign government departments and universities and some quasi-public research organizations, as well as such governmental research institutions as the U.K. Atomic Energy Authority laboratories at Harwell and the Naval Research Laboratory in the United States.

The Research Institutes

There are three major research institutes in Ireland. The Institute for Industrial Research and Standards has responsibility for meeting the technological needs of industry, generally. An Foras Taluntais, the Agricultural Research Institute, performs research for the agricultural and food-processing industries. An Foras Forbartha, the National Institute for Physical Planning and Construction Research has responsibility for the building industry, and recently has become concerned with environmental protection, as well.

Table V

Location of Foreign Contacts by the Four Universities

location of contacts	Communication Bond (C_{if})			
	TCD	UCD	UCC	UCG
Great Britain	0.459	0.346	0.264	0.478
university	0.294	0.231	0.181	0.366
research institute	0.156	0.093	0.055	0.116
industry	0.009	0.022	0.028	0
Continental Europe	0.147	0.275	0.195	0.116
university	0.101	0.110	0.139	0.087
research institute	0.046	0.110	0.042	0.029
industry	0	0.055	0.014	0
United States	0.138	0.187	0.167	0.188
university	0.092	0.143	0.139	0.159
research institute	0.018	0.033	0.014	0
industry	0.028	0.011	0.014	0.029
Other Foreign	0.046	0.044	0.097	0.101
university	0.037	0.033	0.069	0.029
research institute	0.009	0.011	0.028	0.072
industry	0	0	0	0
Total Foreign	0.790	0.852	0.723	0.883
North of Ireland	0.101	0.039	0.069	0
university	0.101	0.033	0.055	0
research institute	0	0.006	0.014	0
industry	0	0	0	0

Communication Among the Research Institutes. Interaction among the three research institutes is at a weak to moderate level (Table VI). It is neither as poor as the worst of the university pairings, nor as good as the best. The two newer institutes have better communication with An Foras Taluntais than they do with each other, but communication could probably be improved generally within this sector.

Table VI

Communication Among the Three Research Institutes (Monthly or More Frequent Contact)		
	Communication Bond (C_{ij})	
An Foras Forbartha	An Foras Taluntais	
Institute for Industrial Research and Standards	0.074	0.104
An Foras Forbartha	-	0.210

The Position of the Research Institutes. An Foras Taluntais, the senior of the three institutes,² clearly dominates the institute sector (Figure 2). It is the only institute to show a high level of interaction with other parts of the research community. It is responsible for the majority of contact with the universities, and is the only institute to show a high level of contact with private industry. It must be remembered that the only industrial firms surveyed were those that supported research and development. That necessarily excludes many firms, and perhaps it excludes a higher proportion of the firms served by the IIRS and AFF than served by AFT. On the other hand, the survey in no way prevented individuals in any of the institutes from reporting contacts they had with people in any industrial firm, whether or not it supported R&D. So the results are, at best, a little dismaying. This is especially true for semi-state industry, which does not receive a very great amount of contact from any of the three institutes.

² Although anticipated in its charter by the Institute for Industrial Research and Standards, it actually became a functioning research institute at an earlier time.

— $c_{ij} > 0.30$
— $0.10 < c_{ij} \leq 0.30$
--- $c_{ij} \leq 0.10$

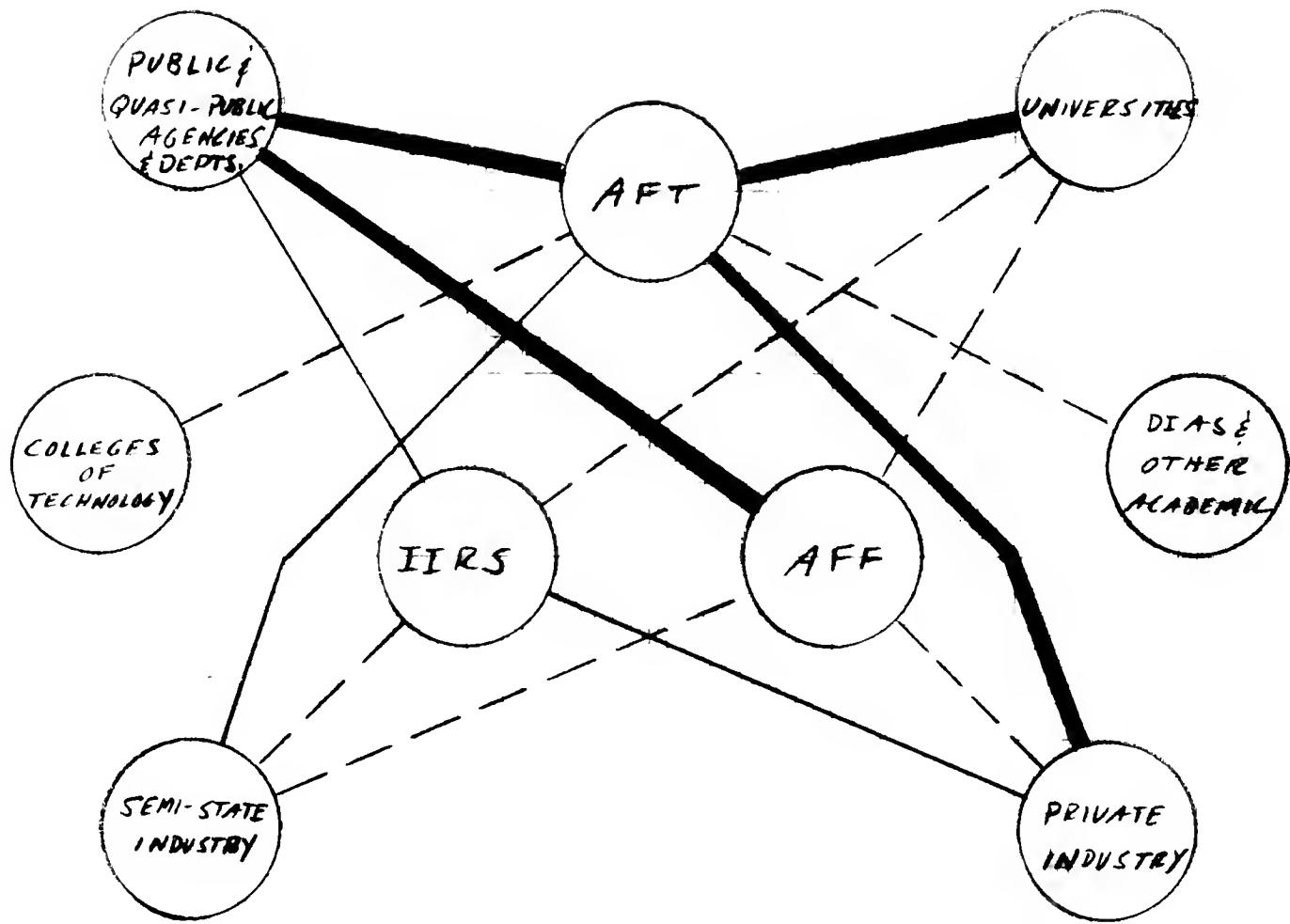


Figure 2. The Position of the Research Institutes
(Based on a Communication Frequency of Once
a Month or more often)

When contacts that occur less often than once a month are included in the analysis (Table VII), there is little change in the results.

Table VII

Communication Between the Research Institutes and Industry
(Yearly or More Frequence Contact)

and between	Communication Bond (C_{ij})		
	IIRS	AFF	AFT
semi-state industry	0.077	0.066	0.261
private industry	0.182	0.057	0.510

There is apparently much that can be done to improve communication between the research institutes and industry.

Foreign Contact by the Research Institutes. The Institute for Industrial Research and Standards has developed the greatest number of British contacts, but reported no contacts outside of Europe (Table VIII). An Foras Forbartha has developed contact in a large number of countries around the world, but the actual number of individuals is still small. It has the lowest index of foreign contact of the three. An Foras Taluntais has well developed contacts throughout the world, and maintains its contacts across a wide variety of institutions. It is the only one of the three that comes even close to the universities in the extent of its foreign contact.

The IIRS could certainly stand to improve its relations with American firms, universities and research institutes. It will probably develop better communication with the continent now that Ireland has joined the

Table VIII

Location of Foreign Contacts by the Three Research Institutes

location of contacts	Communication Bond (C_{if})		
	IIRS	AFF	AFT
Great Britain	0.500	0.200	0.390
university	0.167	0.080	0.084
research institute	0.333	0.120	0.253
industry	0	0	0.053
Continental Europe	0.125	0.080	0.223
university	0	0	0.024
research institute	0.083	0	0.175
industry	0.042	0.080	0.024
United States	0	0.080	0.070
university	0	0.040	0.024
research institute	0	0.040	0.034
industry	0	0	0.012
Other Foreign	0	0.040	0.046
university	0	0	0.012
research	0	0.040	0.034
0	0	0	0
Total Foreign	0.625	0.400	0.729
North of Ireland	0	0.120	0.090
university	0	0	0.060
research institute	0	0	0.012
industry	0	0	0.018

Common Market. The overwhelming contact with British sources is probably not healthy. A broader base of contact might stimulate innovative ideas. An Foras Forbartha is a relatively young organization, and perhaps has not had time to properly develop a range of foreign information sources. It should certainly pay attention to the critical need in a small country to maintain a foreign network of information sources.

Communication Among Other Parts of the Research
and Development Community

The network for the remaining portions of the R&D community is a somewhat sparse one (Figure 3). With the exception of the block called "other public agencies and departments,"³ which has strong communication with the medical field and with semi-state industry, there is just very little communication among other agencies.

This network better than any other displays the central role played by the research institutes and universities in integrating the flow of communication in Ireland. Not only do they directly support most of the research and development work performed in the country, but without them, other organizations supporting research would have little or no chance of learning of developments in other organizations.

Much of what has been stated in this report could be taken to be critical of the performance of the universities and research laboratories. That is so because while they are performing reasonably well, that performance could certainly be improved. It is well to put it on the record at this point, that without their contribution to integrating information, the country would be in a very sorry state, indeed.

A More General View of the Network and Discussion

We entered the present study, if not with tightly structured hypotheses, then at least with some preconceptions of what a communication network

³This category includes among others the Departments of Lands, Agriculture and Fisheries, and Industry and Commerce; local authorities; the meteorological service, ordnance survey, geological survey, and forestry service; plus a number of quasi-public agencies, such as the Salmon Fisheries Trust.

RCSI = Royal College of Surgeons of Ireland

MRC = Medical Research Council

DIAS = Dublin Institute of Advanced Study

$$c_{ij} > 0.30$$

$$0.10 < c_{ij} \leq 0.30$$

$$c_{ij} \leq 0.10$$

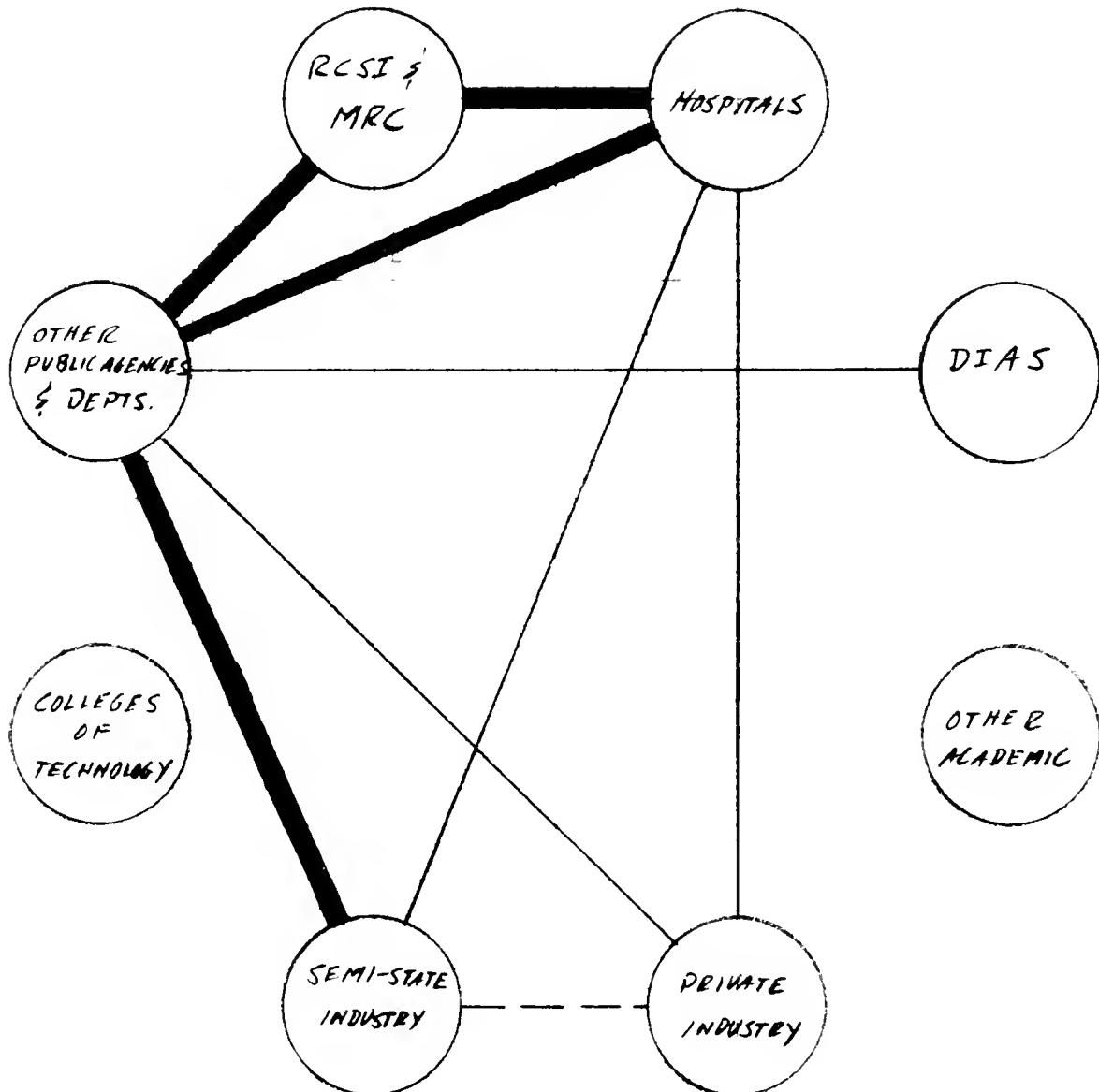


Figure 3. Communication Among Other Parts of the Research and Development Community.

in a small country like Ireland might look like. These preconceptions have not been completely supported, but neither have they been completely denied.

One might expect, for example, that the research institutes would form a buffer stage between less directed research of the universities and the needs of industry. And, in fact, we find that they do play this role, to some degree. Communication between research institutes and universities and between research institutes and industry is much better than direct university-industry communication. But then, not all research institutes are equally successful in accomplishing this mission (Figure 4). Semi-state industry, in particular, fails to receive the attention it needs, either directly or through this buffer stage.

In a similar way, one might expect the universities to be the principal link to foreign sources, with research institutes play a secondary role, with both passing the information along to industry. In fact, the universities do have the most foreign contact, but they communicate little of this information directly to industry. Moreover, the research institutes, generally, have neither the amount or diversity of foreign sources that industry itself has developed. Partly through the mechanisms of foreign ownerships, but largely through sheer need (Cf. Allen and Reilly, 1973), industry has been forced to develop its own foreign information sources. This is not an entirely unsatisfactory situation, but it does have several discomforting features. If the universities or research institutes are the sources of foreign technology, that technology should be available to industry generally. If an industrial firm learns of a foreign development, competitive pressures and the general isolation of the individual firm tend to severely limit the dissemination of that information.



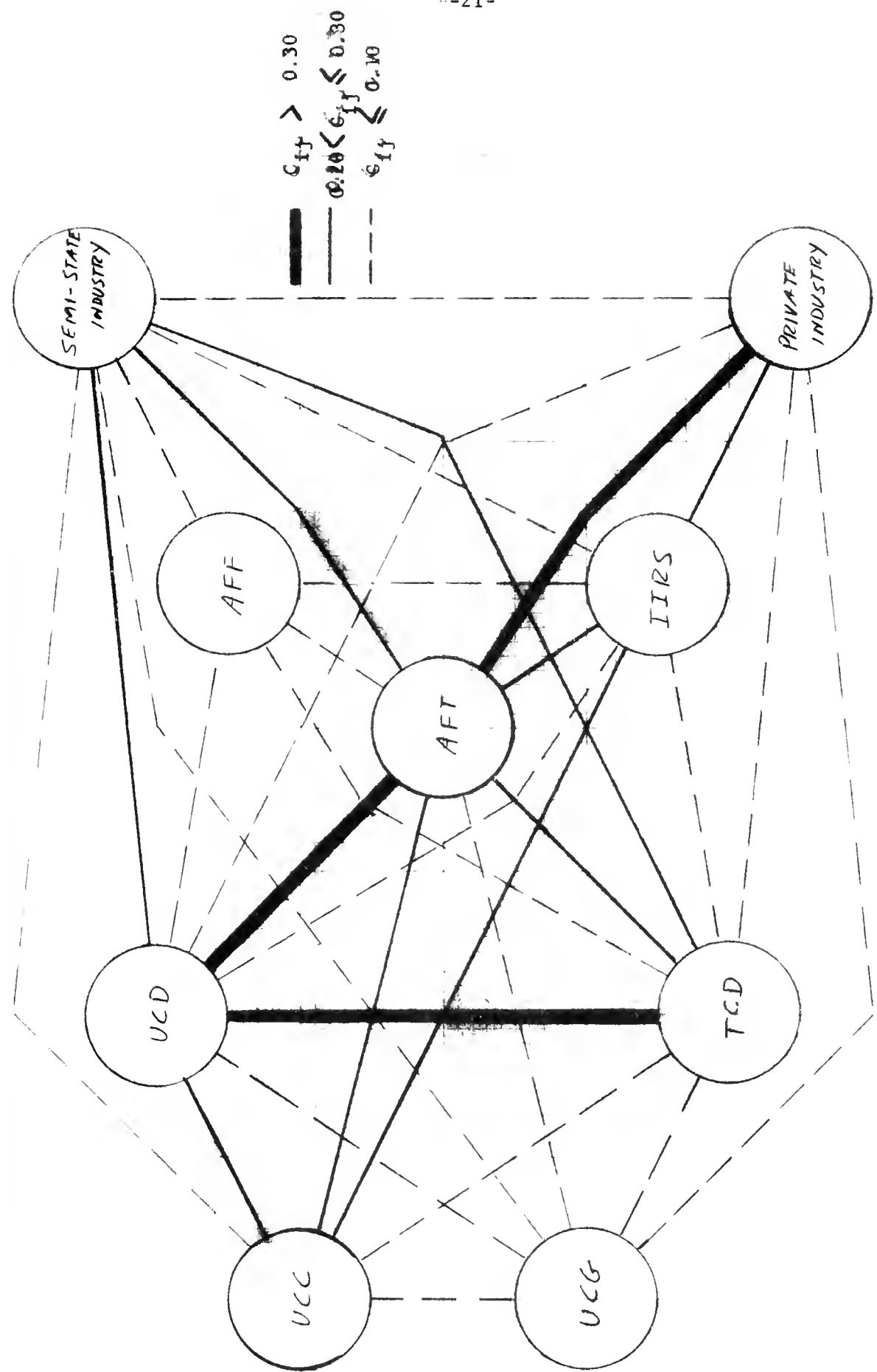


Figure 4. Level of Monthly Contact Among Major Research Institutions

Conclusions

It is clear from all of this that the research institutes could do much to improve their foreign contact networks. There are many ways of doing this but the authors will refrain from making specific recommendations at present. A subsequent report in this series will examine the relative effectiveness of various devices in developing foreign contacts.

It is also quite clear that much can be done to improve sector to sector and intrasector communication. Within the university sector, for example, particular concern should be given to the position of University College Galway, and Cork is not much better off. Similarly in the case of the research institutes. Once again hard recommendations will be withheld for the time being. However, we cannot resist the temptation to hint that labor mobility may be the governing factor in inter-organizational communication. A forthcoming report will explore the effect of labor mobility and other factors on inter-organizational communication.

Gatekeeping Institutions? Are there institutions which function as Allen's (1971) gatekeepers, bridging the gap between domestic and foreign technology? The answer must only be a partial yes. In Ireland, there is one organization which appears to fulfill this role. An Foras Taluntais has both a high enough degree of foreign contact and a sufficient amount of communication with other domestic organizations to be considered a gatekeeper. The other two research institutes are lacking in one or the other of these regards. The universities have the foreign contact, but are isolated from all but the public sector. Perhaps they are gatekeepers for some of the organizations in that sector, but they certainly do not perform the role for industry.

A subsequent report, in this series, will examine the backgrounds of personnel in the universities and research institutes and see why some organizations play a gatekeeping role, while others do not. More important, recommendations will be made for actions to improve the functioning of this institutional system.

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